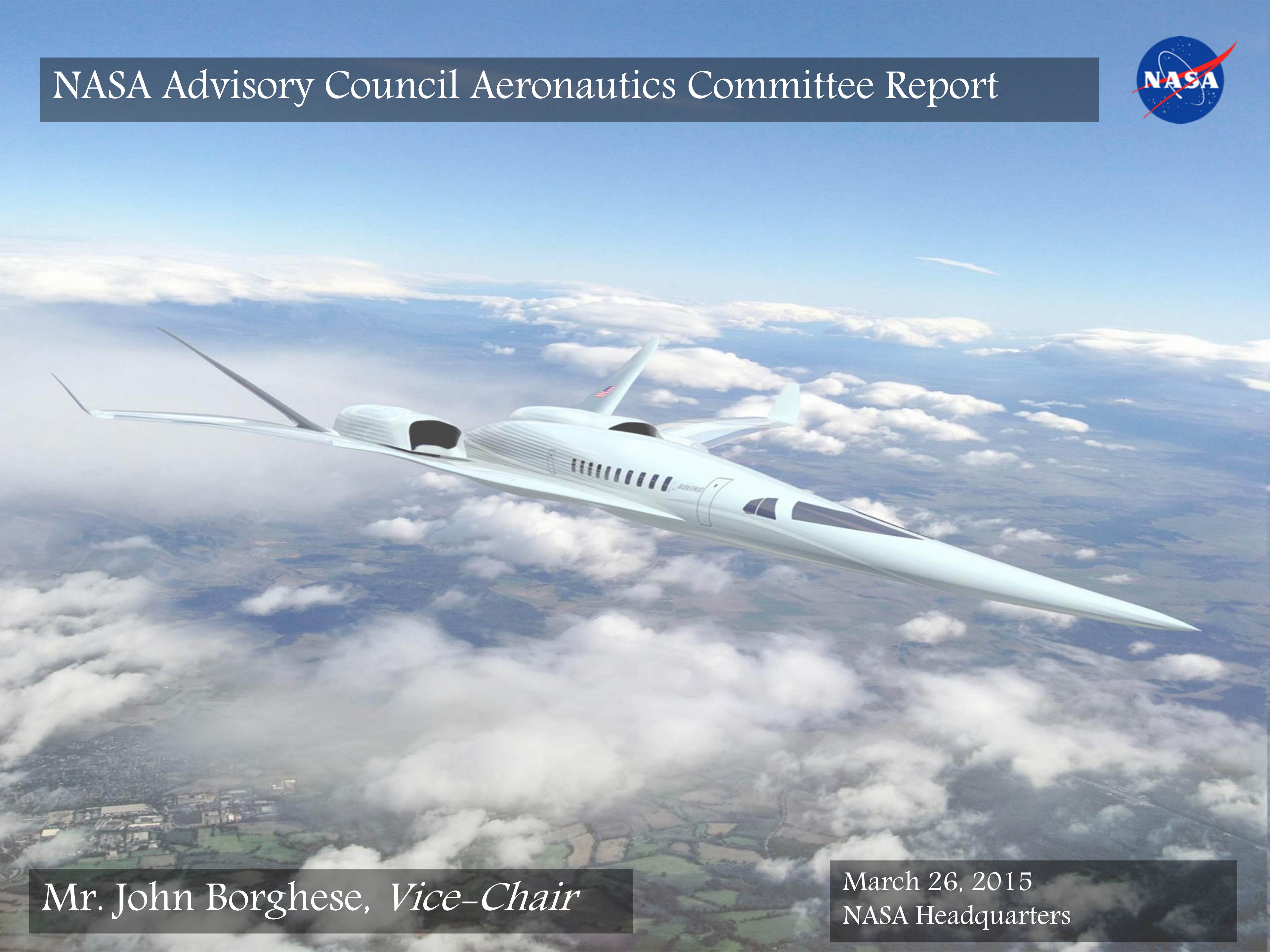
NASA Advisory Council Aeronautics Committee Report



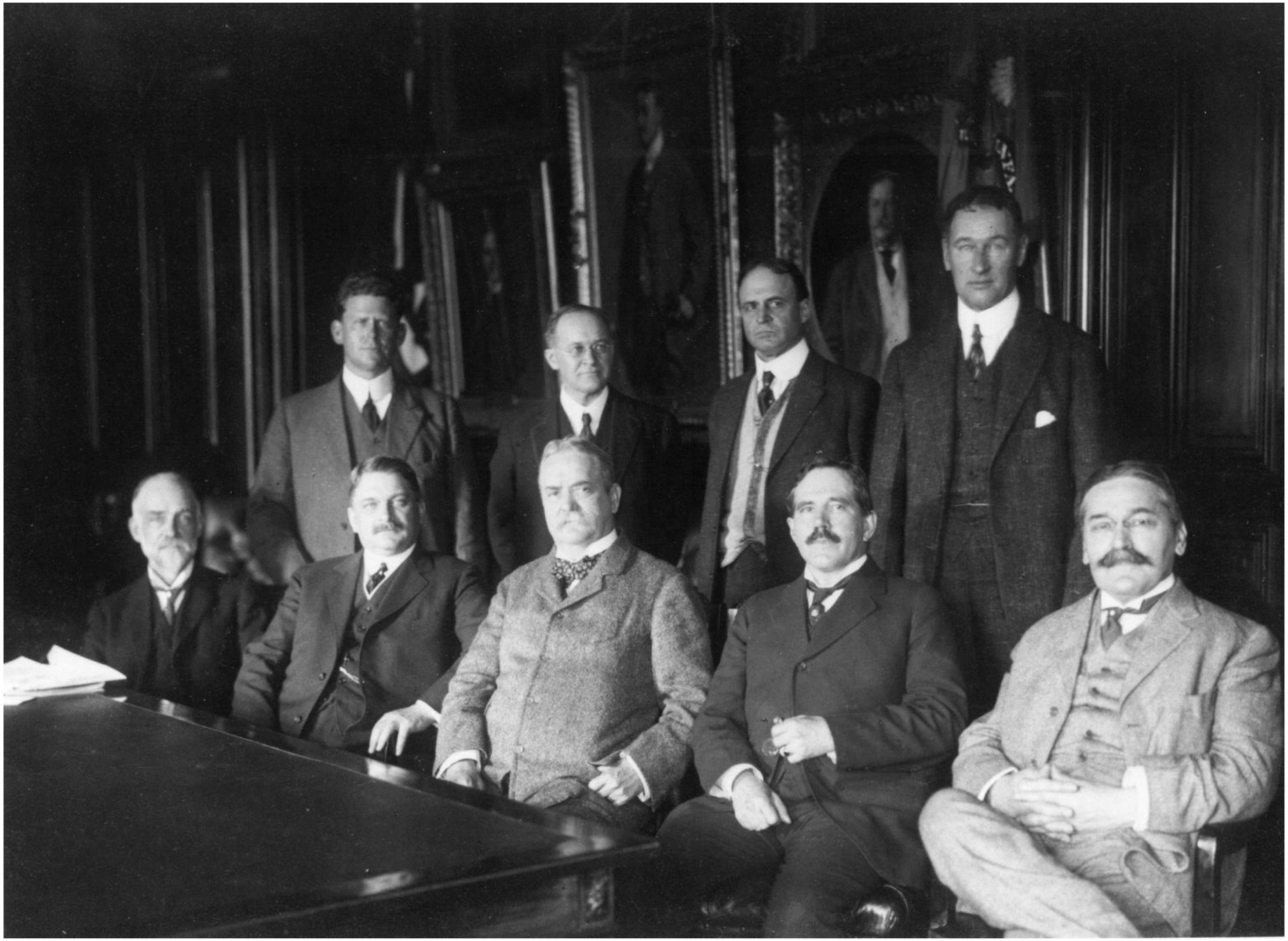
Mr. John Borghese, *Vice-Chair*

March 26, 2015
NASA Headquarters

National Advisory Committee for Aeronautics

First Meeting…..

April 23, 1915
Office of the Secretary of War



NASA Advisory Council Aeronautics Committee

…..100 Years Later

March 26, 2015
NASA Headquarters

Seated (L-R): Mark Anderson (Consultant), John Langford (Aurora Flight Sciences), Marion Blakey (AIA), John Borghese (Rockwell Collins).
Standing (L-R): Stephen Morford (Pratt &Whitney), Michael Francis (UTRC), John Paul Clarke (Georgia Tech)
Not Present: Karen Thole (Penn State), Tom Wood (Bell Helicopter)

Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee meeting held on March 26, 2015 at NASA Headquarters:

Aeronautics Committee Work Plan

Aeronautics FY2016 Budget

Innovation in Commercial Supersonic Aircraft Strategic Thrust

Safety Program Reorganization Implementation*

ARMD Investment Strategy*

Cross-Agency Aviation Issues

* These topics have related recommendations or findings provided by the Aeronautics Committee

CY2015 Committee Work Plan

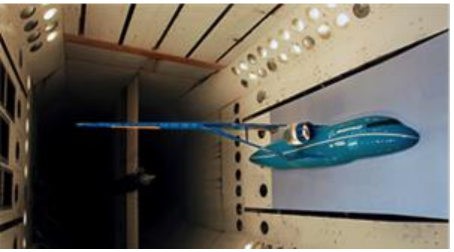
1. Review reorganization implementation specifically focusing on the former Aviation Safety Program (AvSP). Provide feedback on current implementation and if critical areas of safety research are being adequately addressed across the current portfolio.
2. Review study progress/outcomes from the National Research Council-led Low Carbon study and, if applicable, recommend follow on ARMD activities.
3. Review the outcomes, research themes, and technical challenges associated with the "Innovation in Commercial Supersonic Aircraft" strategic thrust. The Committee will provide guidance on ARMD strategies in this area and advise on any research content improvements or gaps.
4. Review NASA Aeronautics' approach and progress for building and sustaining interagency partnerships and advise on ways to enhance and leverage stronger collaborations.
5. Provide guidance on NASA Aeronautics' approach for implementing OSTP and Agency guidance regarding increasing access to the results of federally funded research.
6. Provide guidance on NASA Aeronautics' Global ATM collaboration approach and progress for access to test beds, data, and complementary research and advise on ways to enhance and leverage stronger US industry participation in the collaborations.
7. Review the ARMD ten year investment strategy and advise on ways to improve the portfolio investment decision-making process.
8. Provide guidance on NASA Aeronautics' roles and approach to coordinate with other government agencies and industry for issues that are critical to the successful introduction and/or implementation of NASA-developed technologies for the U.S. for the U.S. aviation industry. Rising costs and complexity to meet growing certification requirements, especially in software certification, pose great difficulties for industry to introduce innovative new technologies. NASA's efforts in V&V and various tool development must be conducted with full awareness of current and emerging concerns and issues associated with certification. While cyber-physical security and UAS privacy issues are not part of the main research portfolio, NASA Aeronautics' needs to have full awareness of and robust coordination with the community in order to maximize NASA's effectiveness of transferring its technologies to the community.

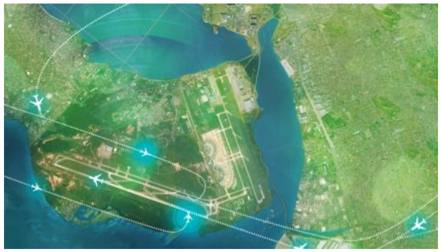
FY 2016 ARMD BUDGET

FY 2016 Budget

Budget Authority	Actual FY 2014	Enacted FY 2015	Request FY 2016	FY 2017	Outyears are Notional FY 2018	FY 2019	FY 2020
Aeronautics	**$566.0**	**$651.0**	**$571.4**	**$580.0**	**$588.7**	**$597.5**	**$606.4**
Airspace Operations Safety			142.4	153.2	159.6	160.0	163.0
Advanced Air Vehicles			243.2	243.2	241.2	231.0	232.8
Integrated Aviation Systems			96.0	85.6	89.0	101.6	104.8
Transformative Aeronautics Concept			92.1	98.0	98.9	104.9	105.8
Aviation Safety	80.0						
Airspace Systems	91.8						
Fundamental Aeronautics	168.0						
Aeronautics Test	77.0						
Integrated Systems Research	126.5						
Aeronautics Strategy and Management	22.7						

FY 2016 Budget Highlights






World leading UAS integration research:
- Unmanned Aircraft Systems (UAS) in the National Airspace System.
- UAS Traffic Management (UTM) System for small UAVs operating under 400 feet altitude

Transformative concepts and technologies:
- Revolutionary hybrid gas-electric propulsion system

Continued success in transitioning NextGen Air Traffic Management (ATM) technologies to FAA:
- Flight-Deck Interval Management Avionics for ATM Technology Demonstration-1 and prepares for future flight trial validation

High-Impact collaborations to reduce aircraft environmental impacts:
- Flight demonstrations to mature environmentally friendly technologies
- High-fidelity validation experiments to improve computational tools for aircraft design

FY 2016 Major Budget Changes

The Aeronautics FY 2016 budget includes increased funding of new strategically important activities including:

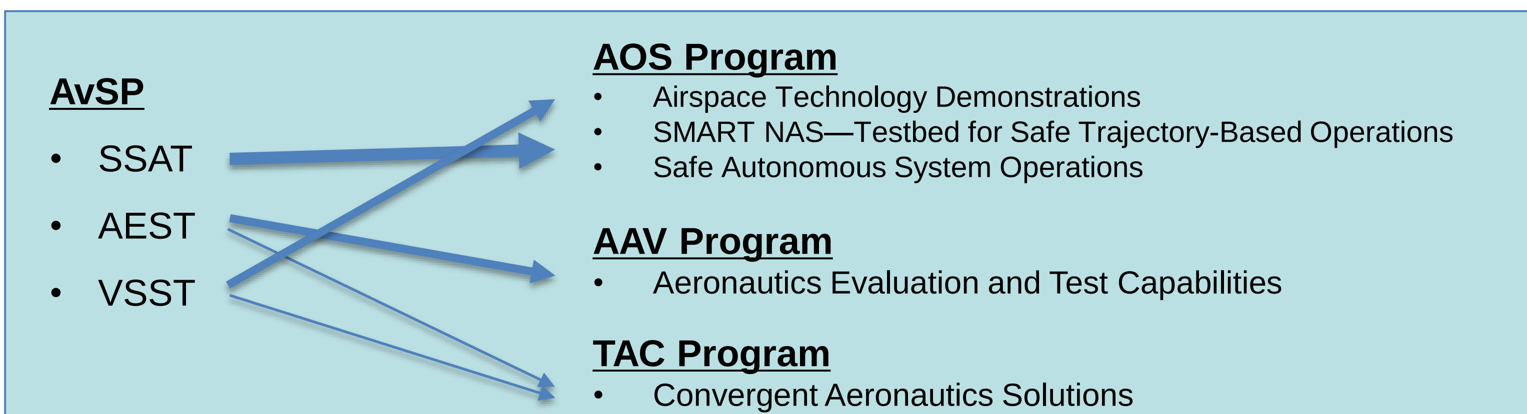
- Flight demonstrations of promising vehicle technologies that enable additional efficiency and environmental benefits for future generations of aircraft
- Development of autonomous concepts, technologies, and procedures that will enable safe operations of Unmanned Aircraft Systems in low altitude
- Low-carbon propulsion research exploring new technologies such as hybrid electric propulsion systems
- Fundamental hypersonics research to ensure sufficient availability of NASA expertise and capabilities to the DOD
- Convergent research to generate breakthrough new ideas integrating traditional and non-traditional aeronautics technological advancements

AVIATION SAFETY PROGRAM REORGANIZATION IMPLEMENTATION

Safety Program Reorganization Strategy

- ARMD Vision
  - Pursue innovative solutions in all Programs aligned to the Strategic Thrusts
  - Enable all Programs to clearly define most compelling technical challenges and retire them as supported/required by stakeholders
  - ➢ Integrate safety research

- Strategy for Integrating AvSP Content into new Organization
  - Continue to be prognostic and be more safety-focused across the system
  - Focus on current operational aspects where NASA has key skills to contribute
  - Be forward looking for safety in all considerations of future vehicles



Committee Finding for ARMD AA

The Committee endorses the approach that ARMD has taken to maintain its commitment to Aviation Safety research even though it will no longer exist as a standalone program in the current organization restructure. The Committee finds that ARMD has taken a thoughtful approach to embed Aviation Safety research across the other programs, and has maintained those areas especially critical to national needs, such as research in verification and validation.

AERONAUTICS INVESTMENT STRATEGY

Strategic Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

10 Year Investment Strategy

Why a ten year investment strategy?

- Forecast programmatic and budgetary trends—allows for better workforce and facility planning
- Better capture dynamics of strategic investment plans—rolling off and rolling on of Technology Challenges

Key Aspects of Initial 10 year strategy—What are we trying to achieve?

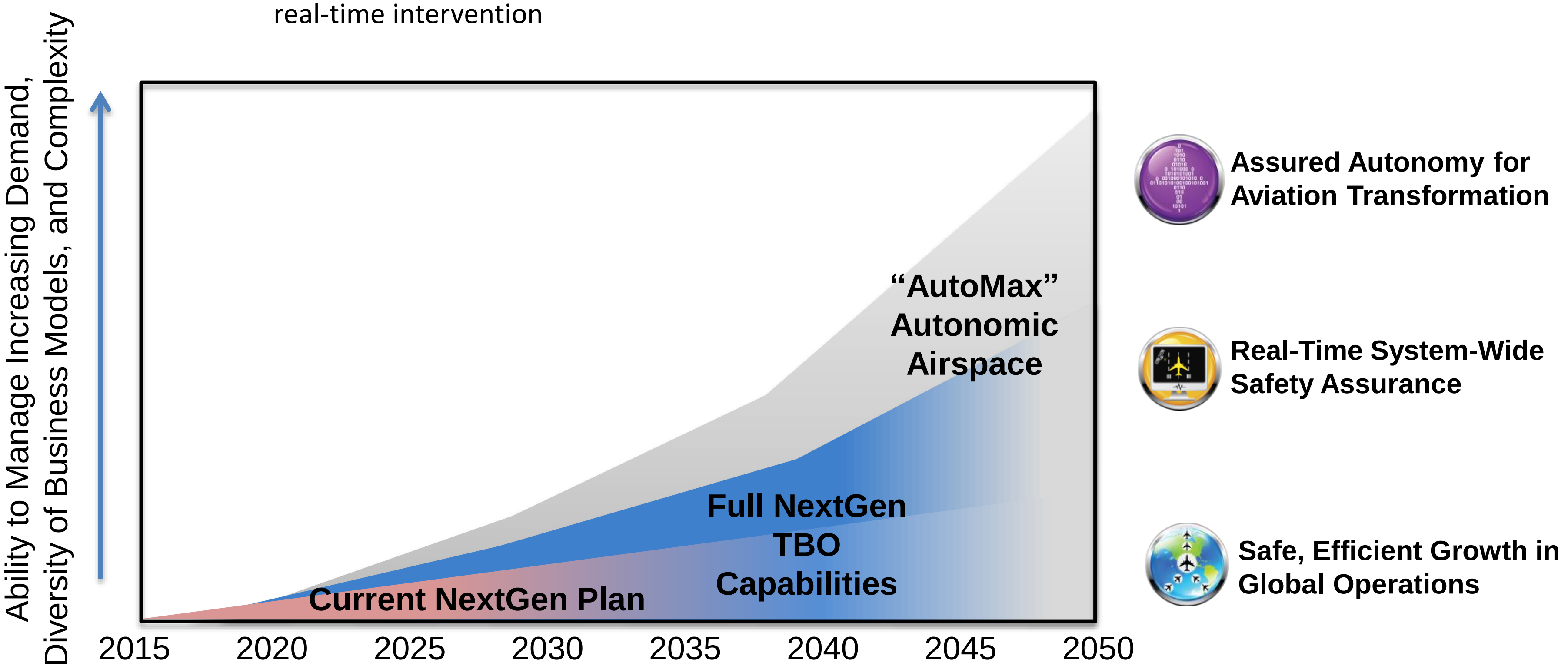
- Phases in expanded investment in “new” Thrust areas—Transition to Low Carbon Propulsion; Real-Time, System-Wide Safety Assurance; and, Assured Autonomy for Aviation Transformation
- Builds in “X-Plane” type large-scale flight demonstrations as both an element of our R&D strategy and to capture the phasing of opportunities to integrate multiple Technology Challenges

Strategic Thrust Outcomes

2015	2025	2035
Improved NextGen Operational Performance in Individual Domains, with Some Integration Between Domains	Full NextGen Integrated Terminal, En Route, Surface, and Arrivals/ Departures Operations to Realize Trajectory-based Operations	Beyond NextGen Dynamic Fully Autonomous Trajectory Services
Supersonic Overland Sonic Boom Standard Based on Acceptable Sonic Boom Noise	Introduction of Affordable, Low-Boom, Low-Noise, and Low-Emission Supersonic Transports	
New Aircraft that Achieve N+1 Levels of Efficiency and Environmental Performance and Technology and Potentially New Configuration Concepts that Achieve N+2 Levels of Performance	Technology and Potentially New Configuration Concepts that Achieve N+3 Levels of Efficiency and Environmental Performance	Technology and Configuration Concepts Including Low-Carbon Propulsion and Autonomy, that Stretch Beyond N+3 Levels of Efficiency and Environmental Performance
Introduction of Low-Carbon Fuels for Conventional Engines and Exploration of Alternative Propulsion Systems	Initial Introduction Alternative Propulsion Systems	Introduction of Alternative Propulsion Systems to Aircraft of All Sizes
Advanced Safety Assurance Tools Reducing Time-to-safety-actions to Days	An Automated Safety Assurance System Enabling Near-real-time System-wide Safety Assurance	Automated Safety Assurance Integrated with Real-time Operations Enabling a Self-protecting Aviation System
Initial Autonomy Applications with Integration of UAS into the NAS	Human-Machine Teaming in Key Applications	Ability to Fully Certify and Trust Autonomous Systems for NAS Operations

Example: Aeronautics Strategy Supports NeededAviation System Evolution

- Thrusts 1, 5 and 6 build upon each other over time
  - Thrusts encompass the capabilities that are envisioned to be needed:
    - To manage increasing **global demand**
    - To manage increased diversity of business models, as represented initially by **UAS**, but ultimately including an expanded range of possibilities that more highly autonomous systems will enable, such as new modes of **On-Demand Aviation**
    - To manage the resulting increased complexity of operations that will be **beyond human cognitive limits** for real-time intervention



Committee Finding for ARMD AA

The Committee strongly supports the strategic approach toward research portfolio management that ARMD has put in place and as reflected by the ARMD Strategic Implementation Plan (SIP). The Committee finds that the SIP is extremely well thought out and forward leaning, and will enable ARMD to approach research portfolio management in a more comprehensive and deliberate manner. In particular, the Committee feels that the SIP addresses the broad range of research efforts in the ARMD portfolio in a balanced manner including both fundamental and integrated research as well as research targeted toward more specific solutions sets such as rotorcraft and supersonic aircraft.

INNOVATION IN COMMERCIAL SUPERSONICS STRATEGIC THRUST

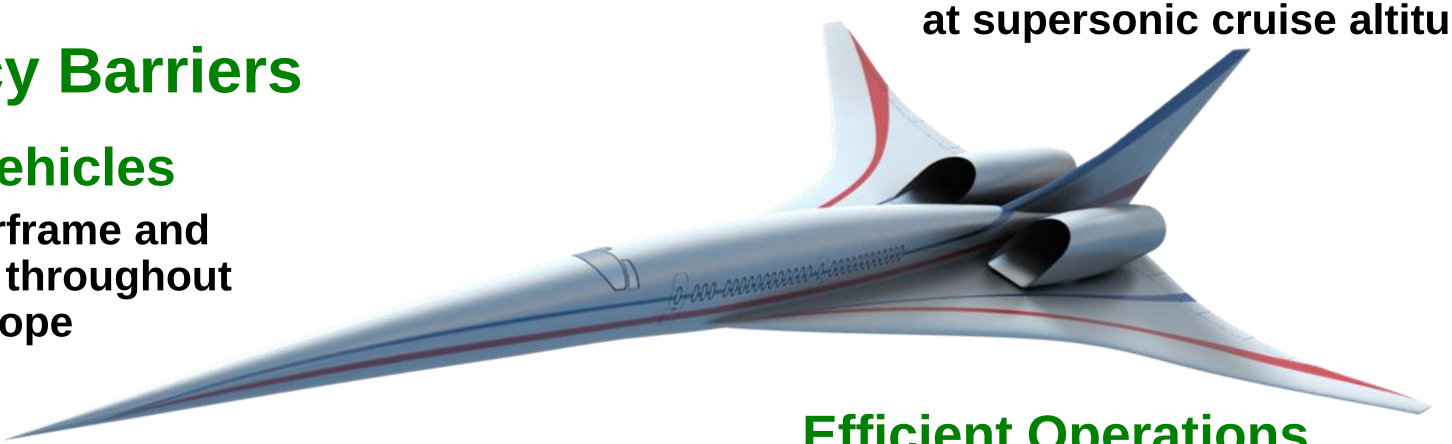
Overcoming the Barriers to Practical High Speed Vehicles

Environmental Barriers

Sonic Boom
- Design for low noise sonic boom
- Understand Community Response

Airport Noise
- Noise levels not louder than subsonic aircraft at appropriate airports

High Altitude Emissions
- No or minimal long term impact at supersonic cruise altitudes



Efficiency Barriers

Efficient Vehicles
- Efficient airframe and propulsion throughout flight envelope

Light Weight, Durable Vehicles
- Low airframe and propulsion weight in a slender flexible vehicle operating at supersonic cruise temperatures

Efficient Operations
- Airspace-Vehicle interaction for full utilization of high speed

Solutions to Barriers Drives Selection of Research Themes

Supersonic Flight Research

- Recent National Research Council reports identify NASA led flight research and a low-boom demonstrator X-plane as key elements of achieving regulatory change and inspiring our next generation

"NASA's flight research programs are most effective when they are focused on achieving innovation in aeronautics."

"…given the progress in low-boom technology that has been demonstrated over the past decade and in light of this research challenge being the principle remaining barrier to routine supersonic operations, NASA together with the FAA could proceed immediately with an integrated technology experimental aircraft program to validate low-boom acoustic ground signatures and establish a set of quantitative criteria for the sonic boom footprint over land."

*"Sonic boom is the major barrier to the development of supersonic business jets (SBJs) and a major, but not the only, barrier to the development of supersonic transports with overland capability… …**While NASA should have its eye on the prize – supersonic commercial transports – it is still quite appropriate for NASA to conduct sonic boom research, even when related to SBJs.**"*

Supersonic Low-Boom Flight Demonstration

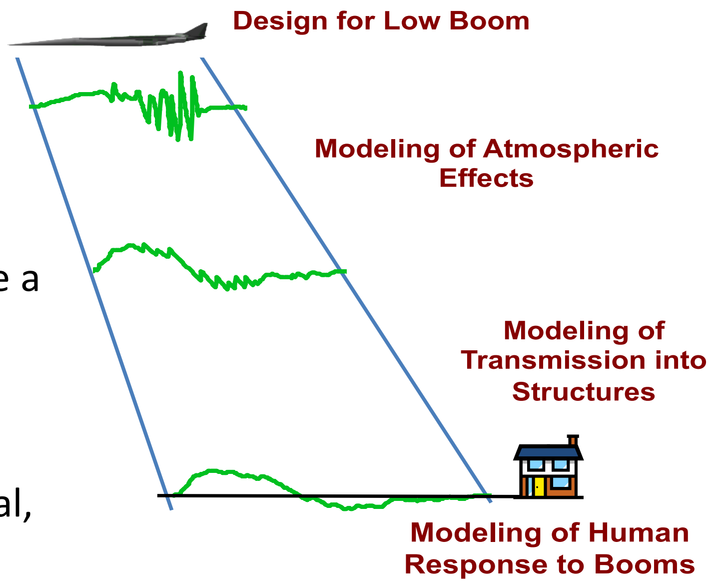
Requirements

- Demonstrate sonic booms can be reduced to a level acceptable for the population.
- Create a community response database and develop a noise based rule for supersonic overflight

Approach

- Partner with regulatory agencies and communities to create a roadmap for community response and rule development
- Revitalize the excitement of X-Planes using a focused and cost-effective low boom research aircraft
- Partner with industry and OGA to formulate, obtain approval, and execute a Low Boom Flight Demonstration Project

Sonic Boom Technical Challenge Elements



NASA is in a position to lead this effort, but Industry, Regulator and Community support and partnership is needed for success

CROSS-AGENCY AVIATION ISSUES: CERTIFICATION

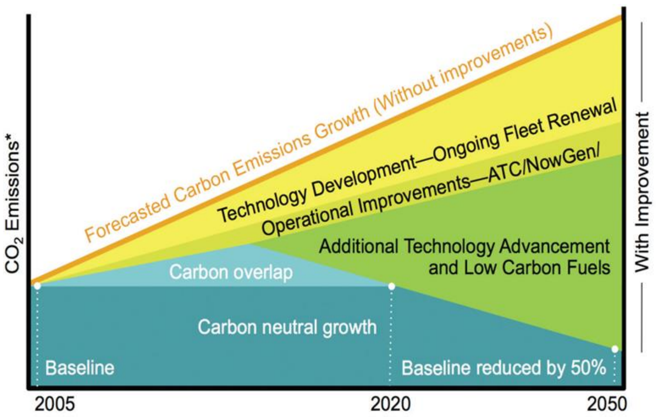
Executive Summary

NASA Mission Statements include:

Ultra-Efficient Commercial Vehicles

Transition to Low-Carbon Propulsion

High Risk, Leap-frog ideas



Transition of NASA innovation to production is *hindered/ jeopardized* by increasing regulation

Effort for certification has doubled between 2005 and 2014

Young Engineers do not see certification efforts as innovation. Leaving industry

Significant certification time, cost and risk are inhibiting NASA innovation from transitioning to new airplanes

- Clean sheet single aisle airplanes delayed: 2020 ➡ 2025 ➡ 2030
- No current plan for N-2 designs

Cost/schedule Impacts Due to New Requirements Can Inhibit Innovation in Aircraft Design

NASA is developing innovative aircraft solutions to meet future aircraft safety, efficiency and CO² objectives

N3-X performance over Boeing 777

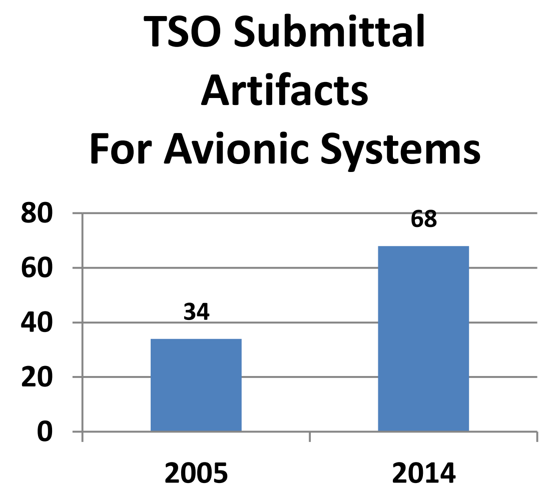
- ~ 63% energy use reduction
- ~ 90% NOx reduction
- 32-64 EPN db noise reduction

TECHNOLOGY BENEFITS*	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum below Stage 4)	-32 dB	-42 dB	-71 dB
LTO Nox Emissions (below CAEP 6)	-60%	-75%	-80%
Cruise Nox Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption+ (rel. to 2005 best in class)	-33%	-50%	-60%

But: Will This Airplane Ever Be Built?

Increasing Regulation is inhibiting innovative design for aircraft electronics

- New guidance mandates:
  - DO-297, DO-178C, DO-331, DO-332, DO-333
- Not written as requirements, but rather as guidelines
  - As such there is latitude in their application
  - And they are open to interpretation
- ARP4754A drives a substantial amount of new
  - Documentation
  - Review overhead (requirements validation)
- Additional guidance being added
  - 25.1302: Human Factors
  - 25.1322: Alerting



- Systems are becoming more complicated
- Avionics Systems artifacts are multiplied by the number of applications
- Subjectivity in the approval process causes rework, delays

Certification causes OEMs to propose what has been certified in the past, not what is the most effective approach